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## Visible Light Electroluminescent Diodes of Indium-Gallium Phosphide

P-N junction electroluminescent diodes that emit visible, orange light have been made from an alloy phosphide of the general formula  $In_{1-x}Ga_xP$ , with  $x$  approximately 0.5. Both vapor deposition and acceptor impurity diffusion techniques have been used.

Indium rich alloys of this type are difficult to prepare because indium monochloride is more stable than gallium monochloride (indium and gallium monochlorides are transient intermediate products in the reaction used to prepare the mixed phosphide), and because indium phosphide (InP) has a higher dissociation pressure than gallium phosphide (GaP). These problems have been overcome by altering the gas flow conditions and by increasing the concentration of phosphine in the gas.

Another major problem is strain in the grown layers, caused by a mismatch between the lattice constants of the alloy and the gallium arsenide substrate, and also by differences in their coefficients of thermal expansion. By growing alloys near the composition  $In_{0.43}Ga_{0.57}P$ , where the lattice constants are matched, the first part of the problem is solved. The problem of thermal expansion has not yet been overcome.

N-type material was grown, and junctions were formed by zinc diffusion. In most cases, light emitting junctions were obtained. The luminescence was dominated by weak, low energy emission and the maximum room temperature efficiencies were only about  $10^{-4}$  percent.

Sharp, flat  $In_{1-x}Ga_xP$  alloy junctions have been grown by vapor deposition. Although the junctions as grown did not emit visible light, annealing for 4 hours at  $800^{\circ}C$  promoted visible light electroluminescence.

Direct band-gap  $In_{1-x}Ga_xP$  alloy electroluminescent diodes are potentially very efficient light sources down to  $5800\text{\AA}$ . Work is continuing on these devices to increase their electroluminescent efficiency.

### Notes:

1. Information on a related project involving gallium nitride is available from NASA Tech Brief 70-10473.
2. The following documentation may be obtained from:

Clearinghouse for Federal Scientific  
and Technical Information  
Springfield, Virginia 22151  
Single document price \$3.00  
(or microfiche \$0.65)

### References:

NASA-CR-86192 (N69-33262), Vapor-Phase  
Growth Technique and System for Several  
III-V Compound Semiconductors

NASA-CR-110194 (N70-28838), Interim  
Scientific Report No. 3

### Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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